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PLATE IX.

Edward Emerson Barnard.
(April 1917, Age 60.)

Early portraits of Barnard.
Upper, both about 1867; Lower, in 1879.

Barnard's first photographic work was to keep this enlarging camera pointed towards the sun. The man on the left is Van Stavoren the proprietor.

PLATE XII.

Region North of Theta Ophiuchi. R. A. 17h 13m, Decl. 21° 0′S.
Scale: 1 mm = 234″. From one of Barnard's Later
Negatives of the Milky Way.

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VOL. XVII APRIL, 1923 No. 3

EDWARD EMERSON BARNARD
1857-1923

By J. A. PARKHURST

OUR profound sorrow at Barnard's death is relieved by thoughts of the rich legacy of memories which he left us. He was an example of the possibilities which America offers to its youth. Nowhere else in the world could a boy rise from such restricted and difficult conditions to such a complete and abundant manhood, honoured equally for friendly character and high scientific attainments. In attempting to sketch his life, one is embarrassed by the multitude of things which should be told to give anything like a complete idea of the man and his work.

Barnard's life falls naturally into three periods. His youth, education and the beginnings of his scientific career in Nashville, Tennessee: his rich contributions to astronomy from the Lick Observatory from 1888 to 1895: his life and work at Yerkes from 1896 to his death.

The story of his early life is most romantic, though some features of his early youth during the war were so sad that he could not be persuaded to repeat them. Born after the death of his father the family endured such poverty that they gladly rescued army hard-tack found floating down the river. Yet in these hard circumstances he learned to be reliable, and his mother found work for

him in the photograph gallery of Van Stavoren because they could depend on him to keep the solar camera, used in making direct enlargements, on the roof pointed towards the sun, while other boys would fall asleep at the task. At the early age of nine he took this job, and soon began his astronomical observations by marking on the roof the position of the shadow of the chimney when the clock in the neighbouring tower struck twelve. But the shadow did not return to the same place at later noons, and so the equation of time was independently discovered. No wonder that he was later called by Sir Robert Ball the foremost observational astronomer in the world.

Barnard's kindly nature once led him to lend two dollars of his hard-earned money to a boy friend, who could not repay the money but gave him instead a copy of Dick's "Christian Philosopher" which uses astronomy as one of the sciences illustrating the relation of nature to religion. This delicious old book turned the attention of the boy to the heavens and thus his life work was determined beyond recall. A lens found on the street was put in a paper tube and made his first spy-glass, then a better lens and a brass tube began to reveal the universe to the eager youth. What ecstasy that meant can be appreciated only by those who have travelled the same road.

Meanwhile the boy was becoming proficient in photography, a fact of greatest importance in directing his future work. He was also making friends, some of whom could aid in his untiring efforts to acquire knowledge. J. W. Braid in his spare time was grinding lenses in the gallery, and best of all, P. R. Calvert came from England and became associated with them in 1875. In 1877 the American Association met in Nashville and Barnard sought advice from the famous astronomer Simon Newcomb, who told him that he could never advance in astronomy without much more mathematics than he knew. Cold comfort to a boy who had had only two months' schooling in his life. But he accepted the challenge.

Barnard's first ride on a railroad took him to Pittsburgh in search of John A. Brashear who was making telescopes in a small way. On arriving at Brashear's home, Barnard was too timid to knock at the door, and paced back and forth till he was weary before he dared make himself and his errand known. Needless to

say he had a hearty reception, and the friendship there begun between such congenial souls was enduring, and so intimate that they were Johnnie and Eddie to each other.

Barnard acquired a five-inch telescope in 1877 and began observing the planet Jupiter, which was destined in after years to add so much to his fame. In January, 1881, he was married to Miss Rhoda Calvert, sister of the Calvert brothers who later managed the photograph gallery. He began that year to make systematic search for comets. His first discovery was made on the morning of May 12, 1881, finding "a very faint comet in the field with the star α Pegasi. No motion was detected between three and four a.m. The following morning it had disappeared from the place but was found again as daylight was whitening the sky, very closely north following α Pegasi, and only visible when the bright star was hidden by the ring-micrometer. No doubt now remaining that it was a comet, Barnard telegraphed to Swift (at Rochester, N.Y.), but neither he nor the discoverer could find it on the morning of the 14th or afterwards. Careful search was made at Boston, Cambridge, Clinton and in other places, but without success." In after years Barnard's reputation would have placed this comet on the list without question, but coming from a young and unknown observer, it was not fully accepted, and it does not appear as his first comet. However, on September 17 of the same year he found that comet known as 1881 VI, and September 13 of the next year, Comet 1882 III.

Bishop McTyeire and Chancellor Garland of Vanderbilt University recognized in Barnard a coming genius and became his life-long friends. In 1883 the latter invited him to take charge of the University observatory, with its 6-inch telescope, and at the same time to take special courses in mathematics, the sciences and language. During his connection with the University, from 1883 to 1887, he discovered seven comets, and paid for his house from the reward of $200 offered for each discovery by Warner of Rochester. For years there was a lively race between Barnard and Brooks, of Phelps, N.Y., in these discoveries. Of the nineteen new northern comets found in 1885 to 1888, Brooks has the credit for eight and Barnard seven, leaving only four for the rest of the world. An interesting by-product of the comet work was his

independent discovery of the Gegenschein, October 4, 1883. He was graduated from the Vanderbilt University in 1887 and the same year was called to the newly organized Lick Observatory, along with Burnham, Keeler, Schaeberle and Hill.

The second period of his life, at the Lick Observatory from 1888 to 1895, was crowded full of productive work, with equipment greatly superior to that at Nashville, in fact the best in the world at that time. As outstanding features may be mentioned his photographs of the solar corona at the eclipse of January 1, 1889, the discovery of the fifth satellite of Jupiter September 9, 1892, his micrometric measures of the diameters of the asteroids, Ceres, Pallas, Juno and Vesta, and the old satellites of Jupiter; but these give but slight idea of his industrious, painstaking and brilliant work during that period. Not long after the solar eclipse of 1889 the 6-inch "Willard" lens was secured, and Barnard began those epoch-making photographs of comets and the Milky Way which endure as perhaps his greatest contribution to astronomy. On account of difficulties in reproduction, the first collection only appeared in 1913 as Volume XI of the Publications of the Lick Observatory, financed by individual subscriptions secured by Barnard himself. The beautiful collotype reproductions of plates of 39 comet and 88 Milky Way fields remain unexcelled in their delineation of these interesting objects.

This is not the place for a catalogue of the important papers on the moon, Mars, Jupiter and its satellites, Saturn with its rings and Titan, the nebulae, comets and Milky Way, published by Barnard during his connection with the Lick Observatory. Suffice it to say that they demonstrate his unrivalled powers of observation and clearness of description, and also his skill in photography, diligently pursued since his boyhood in the gallery at Nashville. He loved California, its mountains, trees, flowers and animals, with an ardour equal to that of a native son. Once on returning to his house at dawn after a night at the observatory, he relates that he was met near the door by a mountain lion. Each eyed the other for some moments with respect, then the lion quietly retired from the scene. Again he met a little dog, evidently a stray. Petting it for a moment he passed on. Soon the dog ran to him yelping wildly. Barnard saw that it had been struck by a snake. He first

killed the rattler and then gave the dog some remedy, but too late to save his life. He afterwards regretted that he had not administered the remedy first and killed the snake later. He and Burnham were in the habit of taking long tramps in the mountains, and many are the exciting tales told of these rambles.

Barnard was appointed astronomer at the Yerkes Observatory of the University of Chicago in the summer of 1895. With Director Hale the staff included Burnham, Wadsworth, Ellerman and Ritchey. His work with the great 40-inch refractor began in the spring of 1897, and ended only with his fatal illness in December, 1922. His ripe experience enabled him to select lines of research which could be continued to advantage over long terms of years. The importance of such long series, coupled with his great ability as an observer, can hardly be over-estimated. Among these, the work on planets and their satellites naturally took a prominent place. The fifth satellite of Jupiter, the fainter satellites of Saturn and all those of Uranus and Neptune, were regularly measured, thus furnishing homogeneous series of greatest value. Of equal length and importance were his observations of Novae. He developed a method of measurements of the colour of these new stars by taking advantage of the colour-curve of the objective and noting the focal settings. He made efforts, without success, to identify Tycho's Nova of 1572. He remeasured the positions and regularly estimated the magnitude of all the old Novae which were visible with the 40-inch.

His most extensive research with the 40-inch was on the clusters.* These were photographed with a yellow colour-filter on isochromatic plates, and also triangulated with great care with the visual micrometer. The final reduction of these measures, which is planned, will furnish not only a most valuable record, but also a comparison between large-scale photographs and visual measures.

The continuation of his photographic work on comets and the Milky Way was made possible by a gift from Miss Bruce of New York in 1897 of sufficient funds to purchase, mount and house a camera of the best obtainable quality. Barnard made his third trip to Europe (December, 1899, to March, 1900) in search of the best

*h and χ Persei, Pleiades, Praesepe, Messier Nos. 3, 5, 10, 11, 13, 15, 35, 36, 37, 41, 46, 50, 52, 53, 67, 92, NGC. 2548, 6709, 6819, 7789.

possible lens. Many samples were submitted and tested, but the lens finally chosen was made by Brashear. The mounting, by Warner and Swasey, held besides this 10-inch lens, a 6-inch doublet which had been re-figured by Brashear, and a 5-inch guiding telescope. This was completed in 1904, used by Barnard in 1905 at Mt. Wilson Observatory on the southern regions of the Milky Way, and since then in the "Bruce" dome at Yerkes in photographing comets and completing his great "Atlas of the Milky Way", which will be published by the Carnegie Institution in the present year or in 1924. This Atlas will contain plates of fifty of the most interesting regions of the Milky Way, the majority being south of the equator. Excluding areas duplicated, they will cover upwards of 2,000 square degrees. The copies are silver prints made on Azo paper by Copelin of Chicago. The scale will average 2′ to the millimeter.

Barnard took part in three successful expeditions for photographing the solar corona at total eclipses In the first, Jan ary 1, 1889, at Bartletts, California, he secured excellent plates with non-photographic telescopes of 9, 23 and 49 inches focal length. At his second eclipse, May 28, 1900, at Wadesboro, North Carolina, as member of the Yerkes party, he used a coelostat of 62 feet focal length, and in collaboration with Ritchey secured very fine results. He was member of the Naval Observatory party at the Sumatra eclipse of 1901, but was unfortunately prevented by clouds from making any exposures. At the eclipse of June 8, 1918, he was a member of the Yerkes party. He took photographs with the Brashear refractor of 12 inches aperture and 18 feet focal length, and was assisted at the 62-foot coelostat by Miss Mary R. Calvert. Although hindered by clouds, both sets of plates were excellent. He was somewhat exhausted by the laborious preparations for the eclipse, and discouraged by the cloudiness, but was nevertheless alert during the following evening and was first of the party to notice Nova Aquilae 3, the discovery of which restored him to his usual freshness of spirit.

Barnard was given honorary degrees by Vanderbilt and Queen's Universities and the University of the Pacific. He was awarded the Lalande, the Arago and the Janssen gold medals of the French Academy of Sciences, the gold medal of the Royal Astronomical

Society, the Bruce gold medal of the Astronomical Society of the Pacific and the Janssen prize of the French Astronomical Society. He was a member of the American Academy of Sciences, the National Academy of Sciences, the American Philosophical Society, and many other scientific associations.

Barnard took great delight in entertaining guests and in imparting astronomical information. His enthusiasm, his wonderful memory and his beautiful photographs, made his lectures rich treats. There were so many similarities in heart and intellect between Barnard and Brashear, that the tribute paid the latter by George M. P. Baird is appropriate for Barnard—

"Son of the toiling many, brother of all mankind,
Pilgrim of starry trails, far-traced to the last sun's bound,
Voyager of sapphire seas, sounder of depth profound,
Meting the pregnant void, reck'ning the bonds that bind
Planet and asteroid, with golden measures of mind;
Heart of a little child, thought of a mage renowned,
Simple of life and aim, humble in vict'ry, crowned
By loves that his heart made warm, and truths that his soul divined."

THE LIFE AND WORK OF TYCHO BRAHÉ

By R A. Gray

(Concluded from last issue.)

At that time Europe was passing through a period of great unrest. The massacre of St. Bartholomew took place on August 25th, 1572, and in November of the same year Tycho was the first to observe the new star. Considerable prestige accrued to him even after his death on account of his prophecies in connection with the star. He claimed that "as the new star of Hipparchus announced the extinction of the Greek empire and the rise of the Roman, so the star of 1572 was to be the forerunner of vast changes in politics and in religion. As it shone with a clear light like that of Jupiter its effect would be first peaceful, then violent and full of tumult. Religions (such as the Roman Catholic) full of 'Jovial' splendour and magnificence which had attracted the people would pass away, and the golden age would be ushered in. After certain planetary conjunctions a great personage would appear about the year 1592, and in 1632 his maximum influence would be felt." Subsequently people believed that the prophecy referred to Gustavus Adolphus who was born in 1594 and who fell in 1632.

All this shows how astrology and astronomy became intermingled in mediaeval times. Later in life Tycho refused to cast the horoscopes of German Kings and nobles, who frequently sought his aid. To similar requests made by his friend and patron, King Frederick II of Denmark, he always turned a willing ear and by so doing he was enabled to make return for the many royal kindnesses in gifts and money that were lavished upon him. Astronomy was in truth more to Tycho's liking than Astrology.

Tycho Brahé showed his originality and his disregard of society conventions by publishing books. It was not considered proper for a nobleman of those days to condescend to write books. Society disapproved also of his marriage. The first of the series of volumes he planned was entitled "The Introduction to the New Astronomy" and contained a treatise on the New Star of 1572. He was com-

pelled to correct star places to which to reduce his earlier observations, and as considerable research had to be made on the motion of the sun, on refraction and on precession, the book grew continually and was not completed before his death. The second volume treated of the comet of 1577 and was published in Latin and printed at his own printing presses. The third volume, also on comets, was not published.

In the second and third volumes he disproved the commonly accepted theory that comets were within the earth's atmosphere, while he accepted the view that they moved in circles like the planets, the moon and the sun.

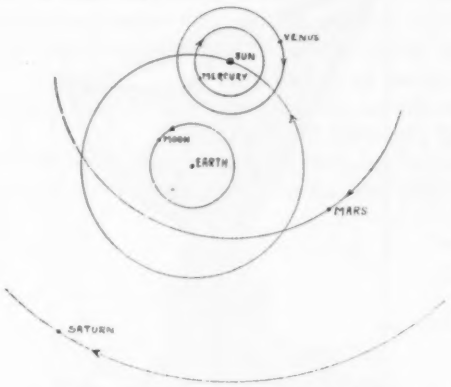

Fig. 2—Tycho's Theory of the Solar System.

Tycho Brahé's views on astronomical distances are interesting, and while they are a distinct advance on previous calculations they fall far short of the real distances.

He used the earth's semidiameter as the unit of measurement which he made out to be 860 German miles or about 3965.46 English miles, the distance of the moon 52 times the earth's semidiameter or 206,204 English miles, the sun 20 times the moon's distance or 4,124,080 miles, Saturn 235 times the moon's distance or 48,457,940 miles.

His rejection of the Copernican theory of the earth's rotation may have been partly due to the fact that he was to some extent

a religious man and accepted—as most people did at that time—the literal interpretation of the Bible. He might have said, like Luther, that the sun must be the moving body, for Joshua ordered the sun to stand still and not the earth.

His theory of the universe was a curious one and can best be explained by a diagram. He claimed that the earth was stationary and that the sun and the moon revolved about it. The planets, however, all revolved about the sun in circular orbits. (Fig. 2).

The claims of Tycho Brahé to a permanent and distinguished place among the great astronomers of the world are largely based on the influence his laborious observations made on the science of astronomy. No progress was possible unless more accurate observations were made on the heavenly bodies, and for this better instruments must be devised.

The cross bar was the instrument much used until Tycho Brahé invented and perfected his sextants.

The cross bar was a very simple though crude device for measuring angles. The rod *AB* was graduated, and the bar *CD*, always

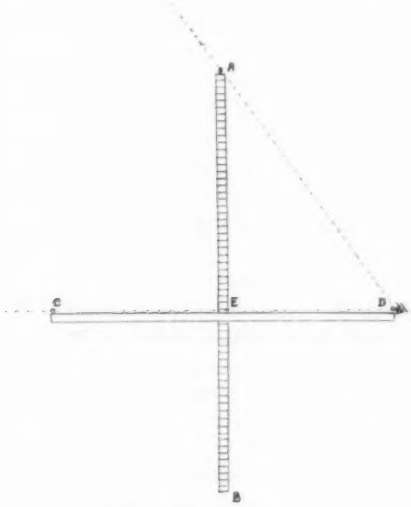

Fig. 3—The Cross Bar.

at right angles to AB, was moved along AB until the observer's eye situated at D saw the two stars whose angular distance was to be found, one in line with the sights A and D, the other with C and D. The distance ED being fixed it is easy to find the ratio AE to ED which is the tangent of the required angle ADC, and from tables of tangents to obtain the angle itself. (Fig. 3).

The improvement made by Tycho is evident from the accompanying cut of one of his large sextants. (Fig. 4).

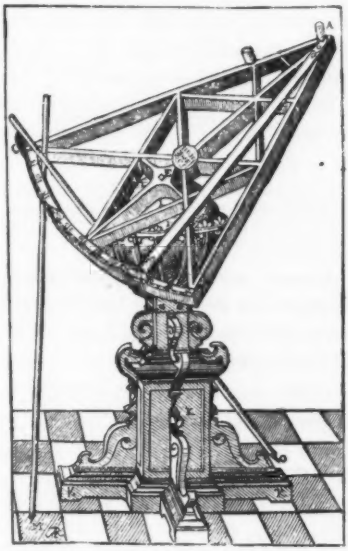

Fig. 4—Tycho's Trigonic Sextant. The arms A B, A C are about 5½ ft. long.

Tycho Brahé was the first to notice the influence of refraction and to make allowances for it in calculating the altitude of the stars. He prepared a table of refractions up to 45°. Beyond that he inferred that refraction did not exist, but this conclusion was the result of his imperfect instruments.

Whenever he observed the heavens he endeavoured to reduce the refraction error by making observations at the highest possible elevation of the object.

He introduced improvements in the art of observing and made allowances for instrumental errors. In order to obtain more accurate observations, it was thought that larger instruments had to be constructed, but Tycho Brahé invented a method of transversal divisions of an arc by points. (Fig. 5).

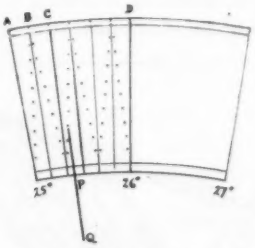

Fig. 5—Transversal dots as used by Tycho. Lines were used later.

The diagram shows a portion of an arc of a quadrant. The arc AD measures an angle one degree in length and is subdivided into six equal parts, each part being 10 minutes; AB is 10 minutes and AC is 20, and AD is 60 minutes.

If PQ, the movable arm that measures the required angle, has rotated from O degrees, the initial position of PQ, the size of the required angle would be 25° together with the angle measured by the arc from 25° to P. Now AC is 20 minutes, but PQ has passed beyond C to the third point beyond C, that is 3 minutes more, the required angle is thus 25° 23′.

He improved the sights of instruments, which made more accurate observations possible. When it is remembered that the days of the telescope had not arrived but that the eye alone was used, the remarkable achievements made by Tycho can be appreciated.

He detected inequalities in the motion of the moon and determined the law governing them.

He made a new catalogue of the fixed stars, comprising some 777 in all, calculated by very laborious methods but very accurately placed on a large globe that he took many years to construct.

Some of his ardent admirers claim that he discovered logarithms and made use of them some years before Napier, but that because of his negligence in publishing his discovery he failed to obtain recognition.

Tycho Brahé found relief from his arduous astronomical labours by incursions into the field of chemistry, or more properly speaking alchemy, the chief object of which was the transmutation of lead and kindred metals into gold. He manufactured a universal elixir which was sold by all the European apothecaries of the time. The peasants of his island he delighted in mystifying by ringing invisible bells in his observatories and by his conjuring tricks.

In addition to his belief in astrology he was very superstitious in other ways, and it is said that he would discontinue a journey if he met a hare or an old woman.

These evidences of weakness of character must be viewed in the light of the age in which he lived and should not be given undue weight in our estimate of one of the most remarkable and epoch-making astronomers of all times.

In the *Edinburgh Review* of 1844 in an article reviewing the just published "Life of Tycho Brahé" by Professor Dreyer of Armagh University, which is the chief repository of information on the subject, this sentence appears: "Excluding his hypothesis respecting the arrangement of the solar system, which never had any followers, and which coming after Copernicus is considered a retrograde step, and considering the extent, accuracy and importance of Tycho Brahé's observations, and the results to which they led, we can conclude that there is no observer, ancient or modern, whose labours have produced a more marked influence on the progress of astronomy."

Toronto, Ont.

WIRELESS TIME SIGNALS OBSERVED AT OTTAWA

By R. Meldrum Stewart

Bulletin No. 3*

Ottawa—Washington Lafayette (G. Sid. T.) ΔT at 10 p.m.

1922 Date	Observed Noon	Observed 10 p.m.	Corrected Noon	Corrected 10 p.m.	1st beat	300th beat	Observed	Adopted
	s	s	s	s	h m s	h m s	s	s
Nov. 1	+.08	+.09	−.03	−.03	22 45 58.71	22 50 51.66	+ 8.944	+ 8.968
2	+.07		−.06		50 3.53	54 56.47		+ 9.176
3	+.02	+.04	−.05	−.04	23 3 55.95	23 8 48.89		+ 9.386
4	+.03	+.02	−.06	−.04	12 5.40	16 58.35		+ 9.615
5	+.02	+.02	−.06	−.05	1 33.98	6 26.92		+ 9.847
6	+.06	+.06	−.02	−.01	11 42.27	16 35.29		+10.087
7	+.07	+.05	−.05	−.03	10 21.59	15 14.62		+10.317
8	+.07	+.07	−.04	−.02	14 53.58	19 46.60		+10.550
9	.00	+.04	−.05	−.04	20 24.44	25 17.46	+10.763	+10.768
10	+.02	+.02	−.05	−.04	22 0.12	26 53.15		+10.992
11	+.04	+.05	−.04	−.04	35 21.30	40 14.32		+11.210
12	+.02	+.01	−.06	−.06	29 6.44	33 59.46		+11.442
13	+.02	+.02	−.06	−.06	32 39.70	37 32.72	+11.679	+11.672
14	−.01	+.02	−.09	−.06	37 24.23	42 17.44		+11.883
15	+.06	+.05	−.07	−.08	40 49.37	45 42.59		+12.101
16	+.04	+.06	−.10	−.05	45 19.91	50 13.13	+12.301	+12.311
17	−.04	−.02	−.10	−.08	48 50.98	53 44.15	+12.509	+12.501
18	+.03	+.07	−.09	−.06	54 7.97	59 1.15		+12.690
19	+.06	+.05	−.09	−.10	0 1 22.51	0 6 15.69		+12.900
20	+.04	+.05	−.10	−.09	1 45.25	6 38.42		+13.096
21	−.02	+.01	−.11	−.10	3 6.73	7 59.90		+13.296
22	−.05	−.05	−.14	−.12	14 16.58	19 9.75		+13.502
23	−.07	−.05	−.14	−.13	12 41.64	17 34.82		+13.694
24	−.03	−.02	−.11	−.10	19 55.82	24 49.00		+13.890
25	−.03	−.06	−.13	−.14	19 19.35	24 12.52		+14.083
26	−.04	.00	−.12	−.10	24 36.00	29 29.17		+14.284
27	.00	.00	−.08	−.09	27 54.96	32 48.13		+14.478
28	−.03	+.02	−.11	−.10	33 11.62	38 4.80		+14.653
29	−.03	−.03	−.11	−.10	34 32.92	39 26.09		+14.842
30		+.01		−.10	40 48.39	45 41.56		+15.021

*For explanations and remarks see this Journal, Vol. XVII, p. 10 (Jan.-Feb., 1923) and p. 79 (March, 1923).

1922 Date	Ottawa—Washington Observed Noon	Observed 10 p.m.	Corrected Noon	Corrected 10 p.m.	Lafayette (G. Sid. T.) 1st beat	300th beat	ΔT at 10 p.m. Observed	Adopted
	s	s	s	s	h m s	h m s	s	s
Dec. 1	−.03	−.03	−.12	−.11	0 50 59.10	0 55 52.27		+15.213
2	−.04	.00	−.10	−.10	48 25.21	53 18.38		+15.413
3	+.01	.00	−.08	−.08	52 43.40	57 36.58	+15.608	+15.624
4	.00	+.02	−.07	−.07	56 2.91	1 0 56.08	+15.829	+15.852
5	+.01	+.04	−.08	−.06	1 0 21.32	5 14.50		+16.093
6	+.06	+.10	−.03	−.01	3 40.78	8 33.96	+16.346	+16.326
7	+.04	+.09	−.02	+.03	6 1.39	10 54.57		+16.572
8	+.08	+.08	+.03	+.02	12 17.07	17 10.25		+16.805
9	+.05	+.05	+.01	−.01	21 29.31	26 22.48		+17.004
10	+.01	+.01	−.03	−.03	18 55.52	23 48.70		+17.184
11	+.02	+.05	−.03	−.02	24 12.48	29 5.66		+17.383
12		+.02		−.04	26 32.89	31 26.06		+17.587
13	−.02	−.03	−.07	−.09	30 51.18	35 44.36		+17.794
14	−.02	−.02	−.10	−.11	36 8.31	41 1.48		+18.023
15	−.05	−.04	−.11	−.11	40 26.23	45 19.40	+18.245	+18.264
16	−.03	−.01	−.09	−.07	45 43.05	50 36.22	+18.531	+18.507
17	−.05	−.04	−.09	−.06	50 0.79	54 53.96		+18.754
18	+.03	+.05	−.05	−.02	52 20.76	57 13.94	+19.010	+18.999
19	+.02	+.03	−.02	−.01	55 39.58	2 0 32.75		+19.232
20	+.07	+.09	.00	+.01	59 57.14	4 50.31		+19.479
21	+.10	+.12	−.01	.00	2 4 14.94	9 8.11		+19.726
22	+.12	+.07	+.02	+.03	8 32.66	13 25.83		+19.982
23	+.09	+.06	+.01	+.03	9 53.93	14 47.10		+20.249
24	+.10	+.10	+.02	+.01	14 11.85	19 5.02		+20.513
25	+.10		+.01		18 29.85	23 23.02		+20.813
26	+.05	+.05	+.01	+.04	22 47.68	27 40.85		+21.069
27	+.06	+.07	+.01	+.03	28 4.23	32 57.40	+21.300	+21.319
28	+.04	+.05	.00	+.01	43 8.87	48 2.04		+21.620
29	+.01	.00	.00	−.02	32 43.73	37 36.90	+21.924	+21.921
30	+.09	+.11	.00	−.02	37 0.81	41 53.98		+22.193
31	+.06	+.06	−.06	−.05	44 14.32	49 7.49		+22.467

Dominion Observatory,
Ottawa, March, 1923.

ASTRONOMICAL NOTES

An investigation of the spectra of visual double stars, by Frederick C. Leonard. *Lick Obs. Bul.* No. 343.

The present paper is of great importance concerning the theory of the evolution of the stars. It adds a little greater weight to the already widely adopted theory of evolution of Prof. H. N. Russell in which a star is supposed to be first a giant M of very large volume and exceedingly low density; this volume while contracting has a spectrum modifying itself gradually and passing first through the giant stages MKGFAB and continuing to pass through the dwarf series BAFGKM. This of course is the case if the star is massive enough. If not, as was shown by Eddington, it cannot reach the early classes but has an evolution MKGFAFGKM or MKGFGKM ... . or MKM . . . according to whether the star is more or less massive.

Mr. Leonard investigated the spectra of the separate components of eighty visual double stars and arrived at the following results:

The spectrum of the secondary component of a dwarf system is generally of a later class than that of the primary, whereas the fainter component of a giant double star is usually of an earlier class than that of the primary. In other words, the secondary component is more advanced in evolution.

The greater the difference of mass between the two components the greater this advance seems to be, the spectral class being the same if the two components have the same mass. The advance, however, is not so marked for double stars whose total mass is large.

The research points clearly to the fact that stars of small masses evolve more rapidly than stars of larger masses, which was already considered to be true from a theoretical point of view.

F. H.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

A Goodly Company of Telescope Makers

A very pleasing story is told in *Popular Astronomy* for March. In Springfield, Vermont, is a well-known factory for making certain machine tools, of which Mr. James Hartness is the president. About a dozen years ago Mr. Hartness designed and constructed the "turret" telescope, a form of refractor which is so mounted that the observer can sit at the eyepiece in a comfortable room. The company employs many machinists trained to accurate work, and when Mr. Russell W. Porter, who had devoted many years to astronomical work in the arctic regions, returned to Springfield three years ago he suggested to some of the workmen that each make a reflecting telescope. Fifteen of them, including one lady, undertook the task. Some of the men had their own machine shops, usually in the cellars of their homes, where they could work on their mountings; but the sympathy of Mr. Hartness contributed largely to the success of the project.

In an unused basement of one of the shops the enthusiasts, under Mr. Porter's guidance, carried on their work. In it they persisted and all but one (who had to leave Springfield) completed their mirrors and all but three have finished their mountings. The ages run from 19 to 67. The mirrors range from 5 to 10 inches in aperture with focal lengths about 8 times the diameter. The general principle of the equatorial mounting was explained to the workers who then carried out the details in various ways.

The result of this admirable experiment is that these people have an excellent knowledge of the mechanism of the heavens as well as a real interest in the celestial bodies,—and indeed in scientific matters generally.

On one occasion the members of the "goodly company" spent a summer's night on the summit of the highest mountain in the neighbourhood. Mr. Porter remarks: "This gathering I believe is

unique in the annals of astronomy. There on a bold rocky pasture were some fifteen men and two reflecting telescopes in good equatorial adjustment. Throughout that summer night, from the appearance of the first star until dawn, these men were exploring the heavens. It proved to be good seeing notwithstanding a stiff wind. The light from a roaring campfire revealed a circle of animated faces listening intently to some celestial fact just brought out at the eyepiece of one of the instruments. It might have been the mechanics of a binary system, or some physical aspect of a planet. For some reason the high school principal had asked permission to join us! It must have been a revelation to him on discovering the mainspring which brought these workmen to the summit of a mountain where they spent the entire night arguing around a campfire."

In the winter there are gatherings at the workers' homes. Here there are discussions on driving clocks and mountings, on home-made spectrometers and interferometers, as well as on general science.

Mr. Porter's concluding paragraph is: "Surely the making and putting into use of a powerful astronomical telescope goes far towards properly orienting one's self in the great scheme of things."

THE DARKENING OF VENUS. (By C. B. HUTCHINGS, OTTAWA).

Anyone who chanced to look up into the southern sky on the morning of January 13 about seven o'clock could not have failed to see the magnificent spectacle of the bright planet Venus resting upon the upper cusp of the crescent moon just as the star was emerging from its occultation with our luminary. Conditions for sighting were perfect, the heavens cloudless and the air clear and frosty. From our dining room window with the aid of a pair of binoculars, my wife and I made a number of good observations of this most interesting celestial phenomenon. Like a sparkling diamond hung in the blue etherial vault, Venus appeared a veritable heavenly jewel set in the upper sloping horn of the silvery crescent moon, an object of rarest beauty and a joy thrilling to behold.

We watched it for fully half an hour as it appeared to pull away somewhat upwards and westwards from the moon, becoming

fainter and fainter every moment, a mere tiny speck of light, soon lost in the golden rays of the rising sun.

(This was received too late for last issue.)

An Interesting Halo Seen in Alberta in 1900

Major Douglas H. Nelles of the Geodetic Survey, Ottawa, writes:

"In the last issue of the Journal I was much interested in seeing Mr. Collier's description of the halo seen by him on February 3. At Lethbridge, Alberta, in the spring of 1900, at about eight o'clock in the evening, in the eastern sky I saw a halo in the shape of three crosses as per drawing. The extraordinary thing in this halo was that the edges of the crosses were as clean cut as if they had been painted upon the sky. The moon was in the centre of the middle and larger cross and I thought my eyes were playing me tricks, but I called three people out from the boarding house in which I was staying and as they all saw the same spectacle, I think it may be taken as a fact."

Halo seen at Lethbridge, Alberta.

Slight Correction to the Handbook for 1923

Mr. J. A. Pearce, who drew the projections of the lunar eclipses, wishes to point out that the times for the first contact and middle of the eclipse of August 26 are correctly printed above the diagram, and that the times given on the diagram refer to the moon's entrance into the penumbra and umbra respectively.

Vatican Observatory Publications Lost at Sea

Fifteen packages of the Vatican Observatory publications, which were shipped on October 14, 1922, and directed to places in the United States, Canada and Mexico, were lost at sea with the

steamer *Matilde Pierce* on account of a fire which had broken out on it. The packages contained Supplementary Charts to the *Atlas Stellarum Variabilium*, a first instalment of the Catalogue of Bright and Obscure Nebulae, and Part II of the *Miscellanea Astronomica*. Duplicate packages are now being shipped to the same directions. This unfortunate accident explains why the places concerned will receive these publications half a year later than others.

Mr. P. van de Kamp, chief assistant at the Kapteyn Astronomical Laboratory of Groningen, Holland, has arrived at the Leander McCormick Observatory, University of Virginia, in order to assist in the measurement of proper motions of Boss stars from the photographic plates taken for parallax determinations at the McCormick Observatory. A year will be spent at the undertaking.

According to the *Jahresbericht* of the German Mathematical Society 31 (1922) 72, Dr. John G. Hagen, S.J., Director of the Vatican Observatory, was elected a Foreign Member of the Royal Academy dei Lincei (Class of Physics and Mathematics).

THE ECLIPSE PLATES FAVOUR THE EINSTEIN THEORY.

On April 4 the results of the measurement of the Einstein eclipse plates taken by the Canadian Expedition were received from Dr. R. K. Young, of Victoria, B.C., who had spent three months on measurement and computation. There is undoubtedly a shift of the star images, and approximately of the amount predicted by Einstein. A telegram received from Director Campbell today (April 12) gives some of his results which even more strongly confirm the Einstein Theory.

C. A. C.

MEETINGS OF THE SOCIETY

AT TORONTO

Jan. 23, 1923.—The annual "At Home" of the Society was held in the Physics Building at 8 p.m., the President, Mr. W. E. W. Jackson, in the chair.

The President, after extending a hearty welcome to those in attendance and after announcing the exhibits and experiments that would be shown later in the evening, read his annual address to the Society on "The work of the Society and the progress of Astronomy during 1922." This contained a comprehensive account of the aims and objects of the Society, with the outstanding features of its work in 1922, after which he reviewed the leading advances in astronomical knowledge during the year. (The address is printed in full in this issue.)

Dr. C. A. Chant, by means of lantern slides and by projecting the spectrum, showed the experiments of Kirchhoff by which he explained the meaning of the Fraunhofer lines in the spectra of celestial bodies. These experiments illustrated the means by which the nature of those distant objects is determined. The dark lines are produced in the spectrum by superposing incandescent gases in the path of a continuous spectrum, sodium being the substance used in this particular example.

Dr. L. Gilchrist conducted experiments to show the relation between light and magnetism by means of the rotation of the plane of polarization of light in a strong magnetic field. This principle was clearly illustrated by means of a vibrating cord as the path of light, and the destructions of the vibrations at will in the cord. Faraday in 1845 first showed the influence on light of a strong electro-magnet.

In the north lecture room, Prof. John Satterly showed some interesting experiments with liquid air, to show the effects of low temperatures. By the use of liquid air, which has a temperature of 331 degrees below zero F., he froze mercury, rubber and various other substances which at normal temperatures are either liquid or elastic. These experiments, from the contrast they offered with what we are familiar with in everyday affairs, proved most interesting and entertaining to those in attendance.

After refreshments had been served in another of the rooms, the assemblage adjourned.

Feb. 6—The regular meeting of the Society was held at 8 p.m. in the Physics Building. Dr. W. M. Wunder in the chair.

The following persons were elected to membership:

Donald F. Smith, R.R. No. 1, Camlachie, Ont.
C. W. Stewart, 39 Pleasant Boulevard, Toronto.
Rev. J. A. Leitch, B.A., Dafoe, Sask.
A. B. Coupal, 289 Church St., Belleville, Ont.
Gen. W. H. Greenly, Trail Farm, Palermo, Ont.
J. H. Skaggs, 830-32 Athens Ave., Oakland, California.
Howard W. McLean, 502 McLean Block, Calgary, Alberta.
Charles I. Tennant, P.O. Box 486, Dawson, Yukon Ter.
Frank R. Hodgens, 233 St. Clair Ave. W., Toronto.
T. A. Whitelaw, 3 Spruce Hill Road, Toronto.
Edward Meek, K.C., 177 Jameson Ave., Toronto.

Mr. A. F. Miller gave the address of the evening on "The Structure of the Atom," in which he described what has been thought of the atom from the earliest historical times to the present. The idea the Greeks had of the atom was that it was indivisible, as the name indicates. Another step was Lavoisier's Law of the conservation of matter, viz., that matter can neither be created nor destroyed. John Dalton's atomic theory came next, by which the constitution of every element is regarded as permanent. Sir Humphrey Davy melted potash with an electric current, getting metallic globules of potassium; this led to the breaking up in a similar way of all the alkalies and alkaline earths. Similarly ammonia, which was named from the temple of Jupiter Ammon, was broken up into nitrogen and hydrogen by the electric current. In these ways, the number of elements was increased, and the atomic theory sustained. Prout advanced the theory that hydrogen is the basic element. Sir Norman Lockyer and others tried to break up the elements into forms of hydrogen, but failed. Then the periodic law, first developed by Newlands and further expanded by Mendeleef, came into use, by which investigators were able to predict the existence of some new elements from the tables, so as to make up a complete series of them. In this way it was possible to account for the existence of 92 elements, although there are gaps which have not yet been filled, but which can be explained. Sir Wm. Crookes, when experimenting with high vacuum tubes, investigating electric discharges through highly rarefied gases which were sometimes luminous from the cathode rays in the tube, made the discovery of electrons. Prof. Roentgen followed with his application of extremely short wave-lengths of radiant energy to photography. Becquerel found that emanations from uranium discharged an electroscope, and by her experiments on pitchblende, Madame Curie discovered radium. This laid the foundation for the modern investigations into the structure of the atom.

The paper was discussed by Messrs. Inrig, Taylor, J. R. Collins and A. F. Hunter, after which the meeting expressed its thanks and was adjourned.

February 20.—The regular fortnightly meeting was held in the Physics Building at 8 p.m., the President, Mr. W. E. W. Jackson, in the chair.

The Secretary referred to a communication he had received from the Treasurer acknowledging the receipt from Prof. C. A. Chant of a donation of $500.00 to the Society's building fund, being an amount equal to the sum the Society had contributed toward his expenses on the Australian Eclipse expedition of last summer, and which he now generously returns to the Society for its building project. A resolution on motion by the Secretary, seconded by Mr. Collins, was unanimously passed for Prof. Chant's generosity in this matter.

Prof. Chant referred to the death of Prof. E. E. Barnard on February 6, and spoke of the great loss astronomy has sustained by his demise. On motion by Mr. Miller, seconded by the Secretary, Prof. Chant was requested to convey the regret of the Society on his death to the Yerkes Observatory and to the University of Chicago.

Miss E. M. Budd read some selections from the poems of Sir Arthur Noyes, the English poet, published in his "Torch Bearers", the first selection being the Prologue on The Observatory (Mount Wilson), and the second on Copernicus. The chairman, Mr. Jackson, pointed out the appropriateness of the selection on Copernicus, as yesterday, February 19, was the 450th anniversary of his birth. These poetical readings were well rendered by the reader, and proved to be an acceptable feature of the programme.

A. F. Hunter, M.A., in his introductory remarks on "Planetary Laws in Atomic Forms", dwelt upon the outstanding work of Sir J. J. Thomson during the last thirty years in splitting the atom. The resemblance between the internal structures and motions of atoms and those of astronomical systems has been noticed by many investigators. He read quotations from the Report of the British Association at Edinburgh in 1921, especially from the Presidential Address of Sir T. Edward Thorpe, on the inner mechanism of the atom and the methods of analysis used by physicists to throw light on atomic structure. In the normal structures of matter, both in the liquid and solid forms, there is uniformity in their tendency to keep the spherical form when there is freedom to move in every direction, and this tendency prevails even in the plant and animal kingdoms, except in so far as their forms are modified by gravity or some other attachment in one of the directions assumed in three-dimension space, so there is no reason to doubt but the same form prevails in the gaseous condition. The ether, at first supposed to consist of free electrons, must necessarily be composed of parts very much smaller than ordinary electrons, and therefore the present analysis of atomic parts into electrons and protons cannot be the ultimate basis of their disintegration, but further subdivision of them will some day be accomplished. The periodic law, as now explained by the new atomic views, as the result of eight gathering foci around every atom, recalls to us the fact that in the solar system there are also eight gathering foci, or major planets. This suggests the uniform method of Nature, working the same way in the very small, as in the very large, aggregations of matter.

Some questions, upon the subject discussed, were asked by Dr. Fraser, Mr. Hooker and Mr. Taylor, and explained. Mr. Miller and Mr. Collins made some remarks upon the subject, and a member pointed out that Swedenborg had

enunciated the principle a century and a half ago that Nature always acts the same whether in a small way or in a very large way.

Prof. Chant spoke of Sir Arthur Noyes' book "The Torch Bearers" as having received much criticism for its defects, but there is much dignity of thought in the poem on Copernicus. Noyes' treatment of Newton is perhaps one of his best efforts, and he recommended everyone to read the book, notwithstanding its defects.

March 6.—The regular meeting was held in the Physics Building at 8 p.m., the President in the chair.

Mr. Leon B. Leppard, 222 Beatrice St., Toronto, was elected a member.

Observations on the partial eclipse of the moon on March 2 were made by the President, Mr. W. E. W. Jackson, by A. F. Hunter, who observed it at Barrie, and by Prof. C. A. Chant, who observed it at Walkerton and who referred to the good photographs of the eclipse which Mr. Balmer of his department of astronomy had secured. He presented a communication on halos from Mr. H. B. Collier in Alberta. The appearance of Beta Ceti called for some attention, and Mr. Miller suggested it might be a close double and long period variable. Mr. Collins spoke of how the date of Easter is determined, which was discussed at considerable length. Great difficulty had arisen during the War as to the fixing of the dates of the Jewish movable feasts on account of the church authorities being Germans.

Mr. A. F. Miller gave the paper of the evening, viz., on "Fraunhofer and his work". The statements about Fraunhofer's life given by the chief authorities do not all agree, and the essayist had to use his own judgment in choosing the correct version amidst the maze of differences. Fraunhofer was the youngest of a family of ten. The paper described his apprenticeship and later career, and his fondness for optics. He was badly injured and was the sole survivor in the collapse of some buildings, which left him maimed for life. The Elector of Bavaria gave him eighteen ducats in this dilemma, amounting to about eight guineas, English money, and became his patron. Fraunhofer then entered into partnership with some friends, in the optical business, and introduced several inventions in their manufactures. He was the inventor of the ruling machine, and constructed a large telescope for the Dorpat Observatory. He also devised the driving mechanism for equatorially mounted telescopes. He also gave much attention to the prismatic spectrum. Mr. Miller showed some lantern illustrations of the inventions referred to, and other illustrative objects.

Although Airy applied the collimator to the spectroscope, we should recognize that Fraunhofer was the inventor of the prism spectroscope. He was also later the inventor of the diffraction grating spectroscope. His death took place June 27, 1826, the circumstances of which were recorded in the paper, which was well received.

It transpired in the discussion that followed the reading of the paper that Wollaston's spectrum observations were not comparable with Fraunhofer's map of the spectrum, and that Fraunhofer knew nothing of Wollaston's work, though it had been done ten years before. Prof. Chant showed a copy of Fraunhofer's paper on diffraction in the original edition.

The meeting, after returning thanks for the valuable paper that had been read, was then adjourned.

AT OTTAWA

The annual meeting of the Royal Astronomical Society (Ottawa centre) was held in the Victoria Memorial Museum, December 12th, 1922. The President, Dr. R. E. DeLury, occupied the chair.

Senator J. G. Turriff was presented for membership by Mr. R. M. Stewart and Mr. A. H. Miller.

Communications from the Toronto and Winnipeg centres were read, which dealt with the matter of lectures at the different centres. These communications were discussed and it was moved by R. M. Stewart and seconded by W. J. Stewart that the new executive pass favourably on the communication, and that furthermore, the executive keep informed regarding the movements of members of the observatory staff or others so that they might be available at the different centres for lectures.

The Secretary's and Treasurer's reports were read and adopted. The reports were very gratifying. The attendance for the past year has been very good, due to a large extent to the lecture accommodation available at the Victoria Museum.

The officers for 1923 were elected. (Their names appeared in the last issue.)

AT WINNIPEG

January 24.—The Society met in Room 21, University Arts Building, and then adjourned to the Geology building for the lecture, which was given by Professor Wallace of the Geology Department of the University. The President, Mr. Allan, occupied the chair.

The subject of Professor Wallace's lecture was "Early Stages of the Earth's History". He discussed the nature of the earliest rocks which the geologist has found in this part of northern Canada. He showed that such rocks had poured out as lavas on a surface which has not been found but which was, in all probability, fused into the granites which later intruded into the lavas. He discussed at some length the relationship of this fact to the hypothesis that has been brought forward to explain the origin of the earth and indicated that, on the whole, geological facts could be better explained by the planetesimal hypothesis. He pointed out, however, that there are yet definite objections on geological grounds to this hypothesis and that its testing will require a long period of geological investigation. He indicated also the possibility of life having existed at a very early period following this intrusion, although the evidences are not definitely obtained until a much later date.

A short discussion followed the lecture, which was participated in by Prof. Wilson, Mrs. Taylor and Prof. Warren. Prof. Wilson expressed the view that the planetary hypothesis offers no advantage over the nebular hypothesis, in explaining the absence of vestiges of an original crust. Mrs. Taylor asked about the application of physics in extending the time assigned as the age of the earth. Prof. Wallace explained that on the theory of an ordinary cooling process applied

to the earth, an age was obtained which is altogether too short for the development of life as it has been traced through geologic ages. Through ring-like markings found about radioactive particles, however, and a method of computing the time required to produce them, the science of physics has shown that these rocks must have been in position for 150 or 200 million years, a length of time greater than that previously estimated by other geological evidence.

February 14.—The meeting was held in the usual place, Mr. Allan, the President, occupying the chair.

The Secretary made an informal report on the prospective purchase of a telescope, and there was some informal discussion of the matter. Hope was expressed that definite action might be taken at the next meeting.

Rev. Fr. Morton then gave the lecture, on the "Einstein Theory of Relativity". Fr. Morton talked it seemed extemporaneously, in a simple and most interesting way, yet setting forth the bases of the theory, both physical and mathematical, in a definite way, and in a most comprehensive way for a single lecture. The following is an abstract of the lecture:

The relativity theory may be called the correlativity theory, for it correlates observed physical phenomena. It serves the great purpose of eliminating the personal viewpoint of events, that is, events may be described without reference to observation from a particular point in space at a particular time. To do this, the most revolutionary ideas of space, time, and gravitation are introduced. To treat these ideas in a mathematical way, modern mathematical methods are required, which omit some of the concepts and axioms of the more classical mathematics which are somewhat familiar to most people. In particular, the classic geometry of Euclid is superseded by a non-Euclidian geometry, or geometry of a non-Euclidian space, originated by Gauss. The distinctive feature of this is, that straight lines are not postulated. For the straight parallel lines of Euclid, Gauss substituted lines which simply do not intersect, with no reference to straightness. We may imagine a rectangular portion of Euclidian space to be occupied by jelly, and points within the jelly to be designated by the intersection of lines running through the jelly and parallel to its edges. One corner is taken as the origin, the three edges coming to it considered as the axes of reference, and the three faces coming together at this point represent three planes from which vertical distances are measured to represent the position of a point within the jelly. Thus if the jelly rests on a table and the observer faces it squarely, a point may be designated as lying 2 inches above the table top, 2.5 inches to the right of the left-hand face, and 3 inches behind the near face. These distances are measured along the straight edges of the jelly, or along any straight lines parallel to these. If, now, we distort this jelly, by twisting or squeezing, its edges will no longer be straight, and lines within it which were straight, become curved, and stretched or contracted, in ways which depend upon the twisting or squeezing. Three straight perpendicular lines intersecting at a point, become three curved lines, still intersecting at the same point in the jelly. Straight parallel lines become curved lines which simply do not intersect. Intersecting lines still intersect in the same points as before. According to the

system of Gauss, points in the jelly are located by measurement along these curved lines, instead of by drawing a new set of Euclidean straight lines through the jelly for this purpose. The lines of Gauss may take complex curved forms, or as a special case, they may be straight, so that the new geometry includes the old. In addition to the geometry of Gauss, the relativity theory treats time as a variable which is co-ordinated with the three ordinary space dimensions, and obtains something analogous to the distance between two points in ordinary space of three dimensions, which is called the interval between two events. The distance between two points does not depend upon the system of lines used to locate the points, and in an analogous way, the interval between two events does not depend upon the mathematical system used to denote when and where these events occur. The revolutionary idea of time and space not being absolute and independent of each other, appears in the consideration of four events, A, B, C, D, having the interval between A and B the same as that between C and D. The idea supported by the relativity theory is that these two intervals may be equal, although the time elapsing between A and B may be different from that elapsing between C and D. The difference in the time part of the two intervals is compensated by a difference in the distances between the points where the events occurred. This is analogous to the case of four points, a, b, c, d, which may be so located that the distance between a and b is the same as that between c and d, though the vertical distance between the levels of a and b may be different from that between the levels of c and d. The relativity theory makes use of the Lorentz contraction, based upon the Michelson-Morley experiment and used by Lorentz in connection with the velocity of electrons, according to which the apparent length of an object becomes less in an east-west direction, in which it may be considered as moving through the ether, than it is when the object lies in a north-south direction, in which it may be considered at rest in the ether. Another fundamental in the theory is, that it treats gravitation and acceleration as being identical.

Summarizing the status of the theory, the bending of the rays of light from a star in passing near the sun, was predicted and computed; a certain discrepancy between the observed motion of the planet Mercury, and the motion formerly computed, is explained and computed; the theory harmonizes with the results of the Michelson-Morley experiment, on which it is largely based; a slowing of a clock or other time-keeping mechanism in a strong gravitational field is predicted, but not verified as yet. A verification of the latter is sought in very exact measurements of the wave-length of light emitted by matter in the sun, where the gravitational field is strong.

Remarks of the greatest appreciation of the lecture were made by C. D. Miller, I. F. Brooks, N. B. MacLean, J. W. Harris, C. E. Bastin and L. A. H. Warren. Mr. Brooks said that he got more out of the lecture by Fr. Morton than out of an article which was awarded a $1,000.00 prize as a popular exposition of the relativity theory, and moved a vote of thanks. Prof. MacLean seconded this motion, and expressed the wish that Fr. Morton give a series of perhaps a

half-dozen lectures on the subject, with suitable arrangements for the series. Mr. Allan called for the suitable expression of the vote of thanks by the Society, after which the meeting adjourned.

C. D. MILLER, *Secretary.*

AT MONTREAL

February 22.—The President, Mr. Justice E. E. Howard, occupied the chair. A letter from Dr. Macdiarmid of Ottawa was read proposing that the two centres act together in future to secure lecturers.

Justice Howard called upon Mr. H. E. S. Asbury, our second vice-president, to address the Society on the subject of "Comets". The following are extracts from this most interesting and instructive paper which was suitably illustrated by numerous slides:

"In all times and in all places comets have exerted a tremendous influence on the minds of men. To the influence of comets have been ascribed such dire disasters as plague, famine, earthquakes, wars, the death of monarchs, etc., and even to this day uncivilized peoples hold such ideas.

The earliest known astronomers—the Chaldeans—considered comets similar to planets in their nature, *i.e.*, permanent bodies revolving around the sun in orbits, so much more extensive that they were visible only when they came near the earth. Greek philosophers paid much attention to astronomical phenomena, and therefore to comets which they thought were produced by a concourse of planets with their combined splendour. But Aristotle pointed out the planets are always confined within the zodiacal band, whereas many comets were seen outside it. Aristotle, himself, thought that comets were in the nature of meteors and their range nearest the earth. It is a remarkable fact, that Ptolemy, nowhere in his writings has mentioned comets. The Romans did not bother much about astronomy, but they looked on the comet of B.C. 43 as a celestial chariot carrying away the soul of Julius Caesar, who had previously been assassinated. In an ancient Norman Chronicle there occurs a curious exposition of the Divine Right of William of Normandy to invade England,—'How a star with three long tails appeared in the sky; how the learned declared that stars appeared only when a kingdom wanted a king; and how the said star was called a Comette'.

The word comet is derived from a Greek word meaning 'long-haired one', the ancients fancying that a comet looked like a woman's head with her long tresses streaming in the wind. Comets are as remarkable for the vastness of their size, and the strangeness, variety, and changeableness of their forms as for the smallness of their masses. They are of such great tenuity that not the slightest effect has been made on any planet by the near approach of a comet; and it is known that the earth has passed through the tail of more than one. But comets are greatly affected by the planets, their speed retarded and accelerated and their orbits changed. Comets when first discovered look like a small round nebula. Later a tail appears. The illumination of the head is not uniform, sometimes a bright central spot is seen which is called the nucleus. The nebulous

haze which always surrounds the nucleus is called the coma. The tails of comets vary infinitely in form: short, long, curved, straight, etc., some indeed have more than one tail, as the great comet of 1744, having no less than six, giving it the appearance of an immense fan.

The tails and even the heads of comets are composed of matter so thin that stars are seen through them without any diminution of their light. The nearer a comet gets to the sun the longer grows its tail. It is unknown exactly of what the tail is composed, but probably of luminous gases, and the theory that electricity operating in some unknown and indefinite way is the primary agent in setting on foot all cometary tails, is now generally accepted by astronomers.

So far as their movements are concerned comets may be divided into two classes: first, those which may be regarded as permanent members of solar system and, second, those which have only once, so far as is known, visited the solar system. Those of the first class are called periodical comets, whose periods may vary from three or four years to thousands of years. A comet can only come back to the sun provided it moves in an elliptic orbit. The chance visitors pursue curved paths known as parabolas or hyperbolas.

When a new comet has been discovered and its elements ascertained, it is usual for some astronomer who specializes on the subject to provide a table of predicted places for the comet many days or weeks in advance. A comet attracted by the sun and so approaching it may have its velocity checked by the attraction of some planet, its orbit then will be changed into an ellipse; were its velocity increased, to an hyperbola.

Encke's comet has the shortest period, viz., 3.29616 years. A French astronomer named Bosler has given much study to the idea that there is a connection between the brightness of this comet and the activity of the sun's surface. His conclusions as a result of the study of 24 returns of the comet, are that there are 12 cases in which its observed brightness has been greater than the calculated brightness, and twelve less; the former, times of sun spot maxima; the latter, at sun spot minima.

The matter of a comet is partly solid and partly gaseous. As there is no central mass sufficient to hold together a continuous atmosphere of elastic gas of any sort, it seems probable that the gaseous particles are only those rising from the coma, possibly by ordinary evaporation but more probably by the action of ultra violet rays and other rays of the sun, giving rise to an ionization of disconnected gaseous molecules. The matter cannot be wholly gaseous because in that case there could be no central force to keep the parts of the comet together.

In the words of C. L. Poor,—'They have been considered as true wanderers, travelling through space, drifting hither and thither just as the sun, with its attendant retinue of planets, is moving onward in some unknown path. When the paths of the sun and such a free comet approach, the attraction of the sun is to the comet like the flame to the moth. The comet flutters for a moment about the sun, and passes on its way. But not unscathed; like the moth, the comet

has been singed; the fierce light of the sun has beaten upon it, and spread out its particles and scattered them along its path.'"

In conclusion, Justice Howard thanked Mr. Asbury for his paper on this fascinating subject given in such a plain and interesting way.

L. SESSENWEIN, JR., *Recorder.*

AT VICTORIA

February 5.—A joint meeting of the Society and the Vancouver Island Prospectors' Association was held in the Assembly Hall of the Victoria High School at 8 p.m.

Doctor Schofield, of the University of B.C., lectured on "The Origin of the Mountains". It was necessary, the lecturer stated, to think of the passage of time in millions of years to adequately realize the changes that had taken place in the earth's crust.

Due to the gradual shrinking of the earth the outer surface was compelled to buckle, thereby forming wrinkles, that is to say, mountains. Probably the last big upheaval was some 10,000,000 years ago, whereas man has only inhabited the earth for some 100,000 years.

A great continent existed where the Pacific Ocean now is and there was an ocean west of Hudson's Bay. This continent sank below the waters and the buckling caused the rise of the British Columbia Coast range and the Selkirk range.

The effects of erosion by rivers and glaciers was described and illustrated by slides, also many others were shown of various mountain formations in B.C., Mexico and Switzerland, attention being directed to the difference in the tops of the mountains according to the climatic conditions, glaciers giving a peaked outline as compared with a rounded outline where they do not occur.

A hearty vote of thanks to Dr. Schofield was passed.

F. MOORE, *Secretary.*

AT LONDON

January 12.—The meeting was held at 8 p.m. in the Normal School Auditorium, Dr. H. R. Kingston presiding. The programme consisted of a lecture by Dr. C. A. Chant of the Department of Astronomy, University of Toronto, on "An Astronomical Trip to Australia". The meeting was open to the public and there was a large attendance. Dr. Chant's lecture had two principal parts, first, a sketch of the people and places visited in the course of the expedition, and second, the purely astronomical side of the trip. Dr. Chant showed a large number of excellent slides and in the first part of his lecture gave many interesting side lights on the people and places visited. The second part of the lecture showed very clearly the vast number of details that must be carefully attended to in preparing for an eclipse expedition, as well as the labour and care required in setting up the instruments in readiness for the making of observations and the taking of photographs.

The lecturer reported that weather conditions were favourable and some good photographs were taken. With these photographs that part of the Einstein theory which deals with the deflection of rays of light as they pass near the sun will be tested.

There were some in the audience who were disappointed because the lecturer could not give the results at the time of the lecture, but the lecturer pointed out that the measurements to be made are very minute and require great care if they are to be reliable. At the close of the lecture a vote of thanks was extended to Dr. Chant.

February 9.—The meeting was held in Room 4, Western University, at 8 p.m., the vice-president, Miss Grace Blackburn, presiding.

It was moved by Rev. R. J. Bowen and seconded by Mrs. Berry and carried:

1. That a letter of thanks be sent to Dr. Chant for his lecture on January 12.

2. That a letter of appreciation be sent to Mr. Prendergast, Principal of the Normal School, for the use of the Normal School Auditorium for Dr. Chant's lecture.

3. That a letter of thanks be sent to Mr. S. Pickles for his kindness in operating the lantern for Dr. Chant's lecture.

Mr. and Mrs. E. H. McKone, R.R. No. 4, London, were duly elected members of the Society.

The major item on the programme was a paper by Miss Grace Blackburn on "Winter Stars in Song and Story", and it was intensely interesting. Miss Blackburn introduced her subject with some interesting star fables but dealt principally with the constellation Orion and the myths that cluster about it. She pointed out that Orion has for all ages been the central figure among the stars—possibly because the natural grouping of stars in Orion more closely conforms to the idea of a titanic human figure—a mighty hunter—such as since the earliest times has been associated with it. It is most frequently alluded to of all the constellations in the literature of the world. Miss Blackburn read extracts from lectures by her grandfather, Rev. John Blackburn, on "The Rise and Fall of Nineveh", selecting those parts which refer to the mighty hunter—builder of Babel, founder of Nineveh, and of his deification and translation to the heavens in the form of the constellation Orion. Miss Blackburn pointed out that in these myths we have first the idea of the several entirely personal gods whose limbs are clothed in divine flesh and whose brows are clothed with divine beauty. And on the other hand collaterally with these corporeal images we have the omnipresent and spiritual influences of fructification and resuscitation and illumination.

Dr. Kingston followed with a short address on "Some Recent Facts Concerning our Winter Skies".

Dr. Kingston described briefly the use of the interferometer in measuring the diameters of some of the giant stars. By means of a lantern slide a diagram was given which showed the relative diameters of the Sun, Arcturus, Belelgeuse, Antares as compared with the orbit of Mars as follows: Sun, diameter 865,000; Arcturus, 21,000,000; Betelgeuse, 215,000,000; Antares, 400,000,000 miles.

Dr. Kingston also described briefly the theory of stellar evolution which considers the stars to pass through the following stages:

1. Diffuse gaseous masses, having low density, low temperature as compared with the sun; red colour.

2. Contract through loss of heat by radiation, but the heat produced by contraction and other sources causes the temperature to rise and the red colour to change to a bluish-white.

3. Contraction continues till the density has increased to a certain point where the temperature begins to fall. The bluish-white light changes to yellowish. This is the dwarf stage of which our sun is a representative.

4. After millions of years a reddish hue appears, finally turning to deep red.

5. Final stage—extinction of light—cold, solid globe.

E. T. WHITE, *Secretary*.

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